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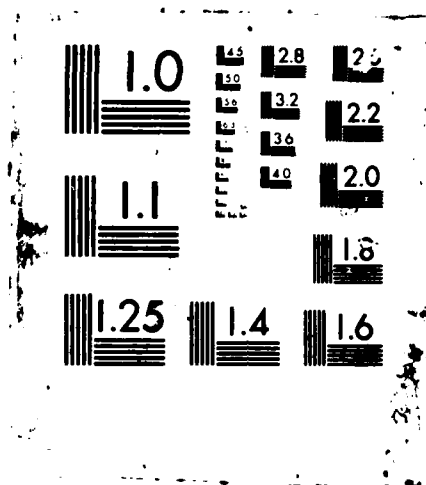
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Submicron Characterization of the Atomic & Electronic Structure
of Defects in Semiconductors

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Final Report

J.C.H. Spence

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) New submicron defect characterisation techniques have been developed, including energy loss spectroscopy and cathodoluminescence in TEM. This has allowed the first observations of infra-red emission from groups of well characterised dislocations in silicon, and the spatial mapping of luminescence in GaAs. The basic theory and corresponding experiments have been developed for coherent bremsstrahlung and electron energy loss spectroscopy (E.L.S.) (in Be ₂ C in particular. ELS allows chemical and structural information to be obtained from subnanometer regions of material. ✓		

1. Statement of problem studied

This research is aimed at developing new techniques for the characterisation of sub-micron defects in semiconductors by electron beam methods.

2. Summary of main results

New submicron defect characterisation techniques have been developed, including energy loss spectroscopy and cathodoluminescence in TEM. This has allowed the first observations of infra red emission from groups of well characterised dislocations in silicon, and the spatial mapping of luminescence in GaAs. The basic theory and corresponding experiments have been developed for coherent bremsstrahlung and electron energy loss spectroscopy (E.L.S.) (in Be_2C in particular). ELS allows chemical and structural information to be obtained from subnanometer regions of material. In addition, a new timing coincidence method for the spatial mapping of carrier lifetimes in semiconductors has been developed, in which the time between electron beam excitation (measured by electron energy loss spectroscopy) and photon emission (measured by cathodoluminescence) is measured (see references). The effects of local crystallographic environment on the near edge "absorption" fine structure of the K shell edges in Be_2C have been measured by E.L.S. and analysed in detail, using multiple scattering "XANES" programs. New emission lines have been observed and studied in undoped LEC GaAs, and in Zn doped GaAs.

More details of the individual projects are given below.

1. We are the first to observe the luminescence spectra of individual dislocations in semiconductors of known character. I consider the paper on dislocations in diamond to be the major return on our effort in constructing the TEM cathodoluminescence apparatus. Using the polarization properties of the luminescence from individual dislocations we were able to develop a theoretical model for their electronic structure.
2. We are the first to observe Coherent Bremsstrahlung (C.B.) effects in electron microscopy, and in axial orientations generally. Since the intensity of this monochromatic X-ray radiation is related to crystal structure factors, we plan to study its use for the analysis of defects in crystals. We have observed strong C.B. effects in many materials, and given a unified Bloch-wave theory of both C.B. and Channelling Radiation.

13. In the X-ray microanalysis of crystalline samples the bremsstrahlung background is concentrated into peaks called coherent bremsstrahlung. By choosing an accelerating voltage such that these peaks avoid characteristic emission lines, the sensitivity of microanalysis may be increased.
14. Carrier lifetimes in semiconductors may be spatially mapped by using coincidence counting between the CL signal and the electron energy loss signal in a TEM.
15. A fourier transform spectrometer has been fitted to a CL apparatus on a TEM instrument in order to obtain infra-red emission spectra from submicron areas in correlation with TEM images. (see refs. for results).

Publications

- A Cathodoluminescence apparatus for TEM. N. Yamamoto, J.C.H. Spence, D. Hazeltine and M. Bergh. Proc. EMSA. (1983). p. 146. (G.W. Bailey, ed. San Francisco Press).
- A Fourier Transform spectrometer for infra-red cathodoluminescence in TEM. J.C.H. Spence and J. Iserman. Proc. EMSA (1983). p. 128 (G.W. Bailey, ed. San Francisco Press).
- Cathodoluminescence and polarization studies of dislocations in diamond. N. Yamamoto, J.C.H. Spence and D. Fathy, (1984) Phil. Mag. B49, p. 609-629.
- Site Symmetry effects in EELS fine structure of Be₂C. M. Disko, J.C.H. Spence and O.F. Sankey. Proc. EMSA (1984) p. 564.
- Electron microscopy and diffraction of phases in the Al₂O₃-BaAl₂O₄ System: N. Yamamoto and M. O'Keefe, Acta Cryst. (1984) B40, p. 21-26.
- Channelling effects in EDS, J.C.H. Spence, German-Belgian E.M. Conf. (Antwerp). Spet. 11-16, 1983.
- The electronic structure of partial dislocations in silicon, J.C.H. Spence and J.R. Chelikowsky, 13th Int. Conf. on defects in semiconductors. (San Diego, 1984).
- Defect structure analysis in semiconductors by HREM and new compatible techniques", J.C.H. Spence. Proc. EMSA (1980) p. 364.
- The structural sensitivity of electron energy loss near edge structure, J.C.H. Spence, Ultramicroscopy, (1985) 18, p. 165-172.
- HREM profile image interpretation in MgO cubes, M. O'Keefe, J.C.H. Spence, J. Hutchison and W. Waddington, Proc. (1985) Proc. 43rd EMSA. meeting 1985. p. 64 (San Francisco Press, San Francisco, CA).
- The energy dependence of axial coherent bremsstrahlung at low accelerating voltages, (1985) J. Butler, J.C.H. Spence, G. Reese, C. Humphreys and R. Doole, Radiation Effects, 84, p. 245.

The electron energy loss near edge structure of Be₂C, (1985) M. Disko, J.C.H. Spence, O. Sankey, D. Saldin, Phys. Rev. B. (1986) B33, p. 5642-51

Cold ALCHEMI: Impurity atom site location and the temperature dependance of dechanneling, J.C.H. Spence, R.J. Graham, and D. Shindo, Mat. Res. Soc. Symp. (1985) Vol. 62 p. 153 (North Holland, New York) (Boston, 1985).

Transmission electron microscopy cathodoluminescence investigation of anomalous Sn diffusion in GaAs, R.J. Graham, J.C.H. Spence, and R.J. Roedel, J. Appl. Phys., 59, pp. 164-7.

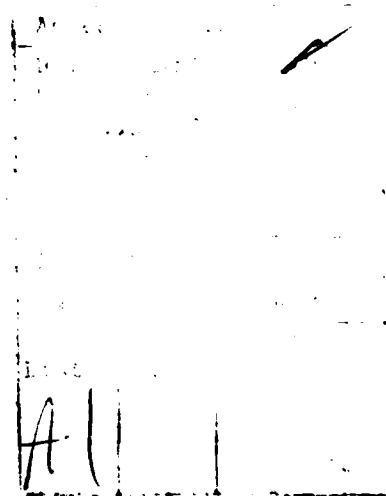
A mechanism for the large anisotropic swelling of DNA films, G. Lewen, S.M. Lindsay, N.J. Tao, T. Weidlich, R.J. Graham, and A. Rupprecht, Biopolymers (1985), in press.

Infra-red cathodoluminescence (C.L.) studies from dislocations in Silicon in TEM, and ELS/Cl coincidence experiments for lifetime mapping in semiconductors, R. Graham, J. Spence, H. Alexander and C. Ahn; Mat. Res. Soc. Symp. Boston, December 1986. (North Holland, New York) p. 153.

Coherent bremsstrahlung - new peaks in EDS, J.C.H. Spence and N. Long (1985) in "Microbeam analysis 1985" (J. Armstrong, ed) San Francisco Press p. 349-354.

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